March 15, 2011

Mr. Michael Bolduc
Public Works Director
City of Saco
300 Main Street
Saco, Maine 04072

Re: City of Saco
Simpson Road Stone Arch Culvert
CLD Reference No. 09-0248.0040

Dear Mike:

As requested, CLD has prepared this summary of completed work and structure condition report for the Stone Arch Culvert on Simpson Road over Stackpole Creek. Included here is an abbreviated project history, structure condition update and a summary of alternatives for the City Council's consideration.

During the course of CLD's most recent inspection of the arch, in January 2011, many of the areas that were previously noted as deficient were found to have deteriorated further. It is CLD's opinion that, given the current condition of the structure and its continued, documented movement a recommendation for road closure will occur in the next 1 to 3 years. This timeframe is notwithstanding an extreme weather event or other causation that could dramatically change the observed integrity of the structure.

What follows herein is an outline of the leading rehabilitation and replacement alternatives sourced from previous studies and updated to reflect the current condition of the structure. Each has been evaluated for its respective advantages/disadvantages, level of impacts (environmental, property, traffic, overhead utilities, historical) and relative cost. A summary of all alternatives discussed has been included as Attachment A.

BACKGROUND

The Simpson Road stone arch culvert over Stackpole Creek is located in the northwest section of the City, off Route 112, close to the Saco/Buxton Town line. The stone arch was originally constructed in 1848 and repaired in 1918, following flood damage in 1916. The abutment walls and wingwalls are constructed of fieldstone that may originally have been dry-laid and then mortared at a later date for repair. The 1918 repair is presumed to have included the concrete that was placed at the northwest wingwall.

The 8'-3" arch span consists of coarsed, ashlar granite masonry, hewn to form continuous horizontal joints. The arch is supported on 15-foot high vertical fieldstone walls. Stone masonry wingwalls extend along the roadway on both sides for about 50 feet, and are almost 25 feet tall at the arch itself.

The project timeline below notes milestone dates that have occurred since the last appearance of this project on the Council's agenda in October 2009:

CLD performed check of arch at request of City	August 2009
City completed roadway repair (gr removal, curb, barrier)	September 2009
CLD installed movement gauges	September 2009
CLD presented bridge status to City Council	October 2009
CLD performed check of arch at request of City	October 2009
CLD performed check of arch at request of City	January 2011
CLD will submit summary report to City Council	March 2011

CURRENT CONDITION

Signs of continued movement have manifested themselves in the form of roadway pavement cracking, mortar loss, sinkhole formation and measured expansion of gaps between arch stones. It is also suspected that some timbers may have become dislodged from the bracing; however this could not be confirmed at the January 2011 inspection due to ice cover. Photos comparing the January 2011 condition to previous inspections have been included in Attachment F.

- **Roadway** – Cracks are clearly visible in the pavement overlay that was placed in September 2009. These cracks generally follow the same pattern that was evident in the previous pavement surface. City personnel noted that two small depressions (starter sinkholes) had developed behind the jersey barriers, just prior to the onset of snow cover. Curbing and drainage appear to be performing as intended.

- **Arch** – At multiple locations, cracks have gotten longer and mortar loss is evident. Photos have been included to show these areas. Additional photos have been included to illustrate how gaps between stones have increased from 2003-04 to 2011. Gauge readings indicate that the upstream third of the arch continues to move outwards.

- **Steel Bracing** – Surface rust covers all of the steel members, and the whalers (more so than the columns or tube sections) have begun to delaminate with notable section loss. This bracing was installed in December 2001 and at that time was considered to be a temporary stabilization measure anticipated to be in place for two-years.

ALTERNATIVES

Alternative 1: Rehabilitation: This alternative involves excavation and replacement of the backfill soils down to the spring line of the arch and the installation of steel reinforcing dowels

and rock anchors to stabilize the abutment walls. Anchors would be drilled through the existing wing stones and into the backside of the abutment wall and the opposing wing, pinning the walls together. Reinforcing dowels would be drilled and grouted through the abutment base course stones into the underlying bedrock to provide reinforcement against wall sliding.

Additional rehabilitation measures would include the following:

- Cast a two-way reinforced concrete slab over the backside of the arch stones to prevent further movement and to assist with load distribution in the arch;
- Install a buried drainage system to collect water from behind the wingwalls;
- Construct a concrete training wall extending from the northwest corner of the waterway opening to reduce the erosive effect of the swirling water pattern in this area;
- Fill voids in the bottom 3+/- feet of the abutment walls with grout to stabilize the lower portion of the walls and keep water out when the creek is at its normal level;
- Fill voids that are higher in the abutment walls with replacement stones, held in place with mortar on their backside where the repair would not be visible; and
- Repoint/replace mortar in all exposed faces of the wings, abutments and arch barrel.

It should be noted that continued movement of the arch and wall stones creates greater risk and increases the construction difficulty associated with this (or any) rehabilitation effort. There remain multiple unknowns associated with how the structure will react when drilling type forces are applied. Careful instrumentation and monitoring of the entire structure will be necessary to ensure that no unintended movement occurs during anchor installation operations. It is likely that this added uncertainty will be reflected in higher contractor bid prices.

In an attempt to reduce the reservations that contractors may have, regarding drilling on the structure, a drilling test program has been given consideration. This program would involve mobilizing a rig for purposes of drilling a series of test holes while monitoring the drill rate and any adverse affects the associated vibrations have on the structure. Instrumentation would be installed that would measure vibration and movement effects during the test program. It is anticipated that this program would cost in the range of $85,000 to $105,000 to implement, if done independently of the full rehabilitation operations.

Because of this considerable cost, if this alternative is selected by the City, it is recommended that such a test program be carried out at the onset of construction rather than prior to. Mobilization, construction of an access route, and instrumentation installation are all items that will be required of the successful contractor. Language can be added to the construction contract that requires the contractor to demonstrate that their chosen means and methods do not adversely affect the remainder of the structure. This way, the costs for these measures are only absorbed once by the City.

The revised cost for the Alternative 1 work is estimated to be $1,700,000. Costs for instrumentation and monitoring of the structure during anchor installation have been added ($30,000) as have the effects of inflation (assumed at 4% per year for each of the past 5 years) as the previous estimate was for construction year 2006.

Advantages

- Preserves the historical character and historical development of the visible structure.
- Addresses geotechnical concerns by providing additional wall reinforcement to increase safety factors for internal and global stability.
- Retains the historical stone arch appearance and presents an opportunity to market the resource as a noteworthy destination site on a local, regional and state level.
- The structure will occupy the same footprint in its pre- and post-construction condition. Minimized long-term property impacts.

Disadvantages

- Addition of reinforcing dowels and rock anchors are modifications that alter the stone masonry, such that the modern structural elements are utilized to resist the applied loads. The use of these contemporary components is not in keeping with the original arch design.
- Retains existing waterway opening and roadway width; neither the hydraulic capacity nor traveled way width will be increased. Unchanged hydraulic opening increases risk to structure from loss of mortar and stones due to higher creek velocities. Smaller opening increases likelihood of snagging debris and of future maintenance costs for removal.
- Careful excavation of existing backfill materials is required to avoid damaging the existing walls. Temporary bracing to support the walls during excavation and backfill operations will be needed.
- Longest anticipated road closure among rehabilitation Alternatives; however, as with any rehabilitation project, unknown conditions are often discovered that require additional cost and/or time to address before work may continue.

Alternative 2: Rehabilitation: CLD worked with CINTEC America Inc. to develop a scope and estimate to apply the ARCHTEC treatment to the arch and for stabilizing the retaining wingwalls. The CINTEC anchors are a proprietary soil anchor system with stainless steel rods in fabric socks that are filled with grout. This alternative would entail installation of anchors to stabilize the arch barrel, abutments and wingwalls. Typically, a finite element analysis for the structure is done by Gifford and Partners (U.K.) who work in partnership with CINTEC. The ARCHTEC methodology calls for a detailed survey of both the vertical walls and the arch along with testing, using both non-destructive and physical means for evaluating the geotechnical (fill and foundation).

Alternative 2 would include the buried drainage, concrete training wall, grouting of voids, wall repointing and the repair and replacement of damaged or missing stones, that were all outlined under Alternative 1. It will also have the same concern over the affects that drilling operations will have on the structure as those elaborated on within the description of work for Alternative 1; however, it is expected that CINTEC America personnel will have greater experience with drilling into and through masonry structures than would a general drilling contractor. As a result, some of the concerns associated with anchor installation would be alleviated, and the instrumentation and monitoring program would not be deemed necessary.

The revised cost for the Alternative 2 work is estimated to be $1,775,000. Effects of inflation (assumed at 4% per year for each of the past 5 years) have been included in this figure as the previous estimate was for construction year 2006.

Advantages

- Preserves the historical character and historical development of the visible structure.
- Addresses geotechnical concerns by providing additional wall reinforcement to increase safety factors for internal and global stability.
- Retaining the historical stone arch appearance presents an opportunity to market the resource as a noteworthy destination site on a local, regional and state level.
- The structure will occupy the same footprint in its pre- and post-construction condition. Minimized long-term property impacts.
- Installation done under the purview of CINTEC America expected to result in enhanced control of the work.
- Anticipated shortest duration of road closure (12 weeks); however, as with any rehabilitation project, unknown conditions are often discovered that require additional cost and/or time to address before work may continue.

Disadvantages

- It is unconfirmed whether the ARCHTEC system can be adapted successfully to address the deficiencies of this particular structure, as the system was designed for longer, more typically proportioned arches.
- Addition of reinforcing dowels and rock anchors are modifications that alter the stone masonry such that the modern structural elements are utilized to resist the applied loads. The use of these contemporary components is not in keeping with the original arch design.
- Anticipated greatest cost of the rehabilitation options that retain the existing stone arch.

- Retains existing waterway opening and roadway width; neither the hydraulic capacity nor traveled way width will be increased. Unchanged hydraulic opening increases risk to structure from loss of mortar and stones due to higher creek velocities. Smaller opening increases likelihood of snagging debris and of future maintenance costs for removal.
- Careful excavation of existing backfill materials is required to avoid damaging the existing walls. Temporary bracing to support the walls during excavation and backfill operations will be needed.

Alternative 3: Full replacement: This option was studied to provide a cost datum to compare with the rehabilitation alternatives. The bridge type considered the most feasible as a replacement structure is a precast concrete arch with mechanically stabilized earth (MSE) wingwalls. A timber structure is also considered a feasible replacement alternative and could be combined with the same MSE walls as the precast option. Hydraulic analysis of the Stackpole Creek and backwater condition from the Saco River found that an approximate 20-ft span x 12-ft rise precast arch will provide adequate area to meet MaineDOT freeboard criteria.

Public comments received at the May 2007 City Council workshop regarding the appearance of a replacement structure were not in favor of using stone covered fill slopes in place of the current u-back walls that parallel the roadway. Generally, fill slopes can be constructed at lower cost than retaining walls, however abutter input has encouraged aesthetic considerations to be weighed more heavily in this instance.

To this end, CLD has investigated the feasibility and costs for multiple aesthetic treatments that could be applied to any new retaining walls. These include:

- Re-use the existing full-size stones to construct a façade in front of the new load-carrying wall. This will require an on-site mason to select stones, set them in place and prepare mortar for stone bedding and joints. It is by far the most expensive and labor intensive option with an estimated cost of $300,000.
- Apply new stones (that are smaller in size) as a veneer over the face of the new load-carrying wall. An on-site mason will prepare the walls first by applying a stucco lath, followed by mortar to provide bedding for the veneer stones. The estimated cost is $130,000.
- Use a concrete formliner, with the option of a stained surface to create the appearance of natural stone. The concrete wall panels will be cast in a bed that is lined with a textured formliner (many patterns are available). The liners can be used with or without stain that will add color and shading to the wall panel. The estimated cost for using the formliner and stain is $80,000. Use of the formliner alone is $50,000.

Photographic renderings of what a new precast arch or timber bridge might look like paired with the aesthetic treatments noted above have been provided as Attachment B. As several different aesthetic wall options are available, a photographic sample of these has been included as Attachment C.

Replacing the structure would allow the opportunity to consider changes in the roadway alignment and width to improve the steep approaches to the bridge from both directions. Additionally, widening the waterway opening would greatly improve the hydraulics, reduce the future maintenance costs (most notably debris removal) and allow the possibility of MaineDOT statewide funding for future maintenance or replacement. Basic sketches of two replacement arch shapes (BEBO and Conspan) have been included in Attachments D and E.

Prior to proceeding with replacing the structure, the following considerations should be taken:

- Design and construction costs for a replacement structure would be the sole responsibility of the City.
- The MHPC will need to be contacted for a PBR requiring approval of the ACOE as the arch has been determined to be eligible for the National Register of Historic Places.
- Replacing the historic structure may result in an ACOE Section 106 process that would involve the study of alternatives to show the purpose and need for removal of the structure.
- Generally, when a historic resource is removed, a Historic American Engineering Record Report (HAER Report) providing detailed plans of the bridge, as well as specially documented photos, would need to be done to provide an exact record of the structure. HAER Report photos and narrative were previously completed; however this information must still be assembled in the specific HAER format and submitted for review.

The revised cost for the Alternative 3 work is estimated to be $860,000, plus any desired aesthetic treatment to the new walls. Costs for the base structure (precast arch) and wall have been revised to reflect current pricing and the effects of inflation (assumed at 4% per year for each of the past 5 years) have been included in this figure as the previous estimate was for construction year 2006.

Advantages

- Barring the selection of wall treatments for aesthetic purposes, this is the least costly option to keep the road open.
- The creek hydraulics would be greatly improved, lessening scour of the streambed and reducing future maintenance costs.
- Provides the opportunity to consider alignment alternatives that improve the steep approaches to the bridge and soften the roadway curvature.

- Addresses geotechnical concerns by providing new backfill material and a drainage system behind the retaining walls, reducing the possibility of concentrated water pressure and the potential for freeze-thaw damage.
- If an arch is chosen it will perpetuate the use of this particular structure form at the site for many years to come.

Disadvantages

- Loss of a historical asset.
- Due to the stone arch having been determined eligible for the National Register of Historic Places, additional documentation and approvals will be needed before its removal.
- If the opportunity is taken to alter the roadway alignment or width, the new structure will have impacts to property that are outside of its existing footprint.
- Anticipated longest duration of road closure (16 weeks); however, due to the nature of a complete replacement project, there are fewer variables and unknown conditions associated with its construction that could affect the construction schedule and cost.

Alternative 4: Do Nothing: In the event that a consensus cannot be reached or budgetary constraints dictate that no action be taken, the "Do Nothing" alternative is an option. Movement of the arch stones is expected to continue; however, the rate at which this occurs depends upon many variables, not the least of which is Maine's unpredictable weather patterns. The more movement that takes place, the more risky and costly the rehabilitation alternatives become.

As stated in the opening, it is CLD's opinion that a recommendation for road closure will occur in the next 1 to 3 years. When closure occurs, the following conditions can be expected:

- Residents and thru traffic will be inconvenienced by the detour;
- Maintenance of the structure (removal of debris) will continue to be an issue; and
- Mutual aid agreements will need to be arranged for fire, police and ambulance services which may result in longer response times.

Advantages

- Lowest cost alternative in the short-term.
- Results in no environmental or property impacts.
- Favorable weather patterns may allow for continued use of the structure.

Disadvantages

- Roadway closure due to continued deterioration and movement anticipated in the next 1 to 3 years.

- Further decline in the structure's condition may rule out any rehabilitation alternative from being feasible.
- Eventual loss of a historic structure.

INTERIM MEASURES

The following measures are presented as ways of providing supplemental fortification of the existing structure. These are intended as means of limiting further deterioration (not preventing it altogether), while a permanent solution is designed, permitted, bid and constructed. It should be noted that implementation of any or all measures discussed here does not guarantee that road closure or structure failure will not occur prior to the full benefit of any applied measures being realized.

Grout bottom stones – This work consists of filling voids in the bottom 3+/- feet of the abutment walls with grout to stabilize the lower portion of the walls and keep water out when the creek is at its normal level. Grout mix design and environmental permitting/coordination will also be necessary due to work occurring in the stream. It is likely that resource agencies will place restrictions on the timing of the work, governing when it can occur.

Work envisioned as part of the grouting process is as follows: limited clearing to simplify access, install sandbag cofferdams and water diversion pipe, replace missing stones (sourced from downstream channel), plug gaps between stones to retain grout behind wall face (will allow for future grouting of walls), inject grout.

The above described grouting procedure details work that would be included in any rehabilitation alternative; however, if a replacement alternative is pursued then this grout would be removed prior to construction beginning on any replacement.

To complete grouting operations, a road closure of up to 2 weeks is expected. This would allow for the contractor to utilize the existing roadway for material storage, without the concern of maintaining traffic through a tight work zone.

The estimated cost for grouting and associated items, including permits, is $55,000.

Additional steel reinforcement – This work would consist of adding horizontal bracing members on both the up and downstream ends of the bridge (at and above the arch springline) and connecting them with adjustable ties (turnbuckles) threaded through the open barrel. The addition of this bracing would restrain the upstream end of the arch barrel from movement and minimize the further widening of gaps between arch stones.

It is expected that work would proceed from the topside and that impacts to the stream, and therefore permitting, could be avoided. Because of the topside work platform, it is expected that road closure of up to 3 weeks will be necessary.

This additional bracing would not add value to either a rehabilitation or replacement alternative and would require removal in either case.

The estimated cost for the design and installation of the additional bracing is $70,000.

SUMMARY

All of the rehabilitation and replacement alternatives presented above are feasible approaches that will allow the structure to once again carry two-lane traffic, without load posting. Each has its own merits, as demonstrated by the listed advantages and disadvantages. The complexity and uncertainties that are associated with design and construction are reflected in the estimated project costs.

As with any public works, the safety of the public must be held paramount. It is with this idea in mind that CLD encourages the Council to deliberate the alternatives presented and request any further information before determining how it would like to proceed.

Please do not hesitate to contact us with any questions, or if more information is required.

Very truly yours,

Robert D. Ricard

Robert D. Ricard
Project Engineer

RDR:kjb

Attachment A – Alternative Comparison (11x17)
Attachment B – Renderings of Replacement Structures (11x17)
Attachment C – Wall Photos
Attachment D – BEBO Sketches
Attachment E – Conspan Sketches
Attachment F – Existing Structure Comparison Photos

Attachment A

Alternative Comparison (11x17)

Alternative No.	Description of Alternative	Estimated Cost	Advantages	Disadvantages
1	**Rehabilitation:** This alternative involves excavation and replacement of the backfill soils down to the spring line of the arch and the installation of steel reinforcing dowels and rock anchors to stabilize the abutment walls. Anchors would be drilled through the existing wing stones and into the backside of the abutment wall and the opposing wing, pinning the walls together. Reinforcing dowels would be drilled and grouted through the abutment base course stones into the underlying bedrock to provide reinforcement against wall sliding. Additional rehabilitation measures would include: 2-way reinforced slab over arch, buried drainage system, concrete training wall, fill voids in lowest 3-ft of abutment walls, replace missing stones and repoint/replace mortar in all walls.	$1,700,000	• Preserves the historical character and historical development of the visible structure. • Addresses geotechnical concerns by providing additional wall reinforcement to increase safety factors for internal and global stability. • Retaining the historical stone arch appearance presents an opportunity to market the resource as a noteworthy destination site on a local, regional and state level. • The structure will occupy the same footprint in its pre and post-construction condition. Minimized long term property impacts.	• Addition of reinforcing dowels and rock anchors are modifications that alter the stone masonry such that the modern structural elements are utilized to resist the applied loads. The use of these contemporary components is not in keeping with the original arch design. • Retains existing waterway opening and roadway width, neither the hydraulic capacity or traveled way width will be increased. Unchanged hydraulic opening increases risk to structure from loss of mortar and stones due to higher Creek velocities. • Careful excavation of existing backfill materials is required to avoid damaging the existing walls. Temporary bracing to support the walls during excavation and backfill operations will be needed. • Longest anticipated road closure among rehabilitation Alternatives. However, as with any rehabilitation project, unknown conditions are often discovered that require additional cost and/or time to address before work may continue.
2	**Rehabilitation:** This Alternative would entail installation of CINTEC anchors in accordance with the ARCHTEC treatment to stabilize the arch barrel, abutments and wingwalls. The CINTEC anchors are a proprietary soil anchor system with stainless steel rods in fabric socks that are filled with grout. Typically, a finite element analysis for the structure is done by Gifford and Partners (U.K.) who work in partnership with CINTEC. The ARCHTEC methodology calls for a detailed survey of both the vertical walls and the arch along with testing using both non destructive and physical means for evaluating the geotechnical (fill and foundation). Additional rehabilitation measures would include: 2-way reinforced slab over arch, buried drainage system, concrete training wall, fill voids in lowest 3-ft of abutment walls, replace missing stones and repoint/replace mortar in all walls.	$1,775,000	• Preserves the historical character and historical development of the visible structure. • Addresses geotechnical concerns by providing additional wall reinforcement to increase safety factors for internal and global stability. • Retaining the historical stone arch appearance presents an opportunity to market the resource as a noteworthy destination site on a local, regional and state level. • The structure will occupy the same footprint in its pre and post-construction condition. Minimized long term property impacts. • Installation done under the purview of CINTEC America expected to result in enhanced control of the work. • Anticipated shortest duration of road closure (12 weeks). However, as with any rehabilitation project, unknown conditions are often discovered that require additional cost and/or time to address before work may continue.	• It is unconfirmed whether the ARCHTEC system can be adapted successfully to address the deficiencies of this particular structure as the system was designed for longer, more typically proportioned arches. • Addition of reinforcing dowels and rock anchors are modifications that alter the stone masonry such that the modern structural elements are utilized to resist the applied loads. The use of these contemporary components is not in keeping with the original arch design. • Anticipated greatest cost of the rehabilitation options that retain the existing stone arch. • Retains existing waterway opening and roadway width, neither the hydraulic capacity or traveled way width will be increased. Unchanged hydraulic opening increases risk to structure from loss of mortar and stones due to higher Creek velocities. Smaller opening increases likelihood of snagging debris and of future maintenance costs for removal. • Careful excavation of existing backfill materials is required to avoid damaging the existing walls. Temporary bracing to support the walls during excavation and backfill operations will be needed.
3	**Full replacement:** The bridge type considered the most feasible as a replacement structure is a precast concrete arch with mechanically stabilized earth (MSE) wingwalls. A timber structure is also considered a feasible replacement alternative and could be combined with the same MSE walls as the precast option. Hydraulic analysis of the Stackpole Creek and backwater condition from the Saco River found that an approximate 20-ft span x 12-ft rise precast arch will provide adequate area to meet MaineDOT freeboard criteria.	$860,000 plus costs for chosen aesthetic treatment of walls	• Barring the selection of wall treatments for aesthetic purposes, this is the least costly option to keep the road open. • The creek hydraulics would be greatly improved, lessening scour of the streambed and reducing future maintenance costs. • Provides the opportunity to consider alignment alternatives that improve the steep approaches to the bridge and soften the roadway curvature. • Addresses geotechnical concerns by providing new backfill material and a drainage system behind the retaining walls reducing the possibility of concentrated water pressure and the potential for freeze-thaw damage. • If an arch is chosen it will perpetuate the use of this particular structure form at the site for many years to come.	• Loss of a historical asset. • Due to the stone arch having been determined eligible for the National Register of Historic Places, additional documentation and approvals will be needed before its removal. • If the opportunity is taken to alter the roadway alignment or width, the new structure will have impacts to property that are outside of its existing footprint. • Anticipated longest duration of road closure (16 weeks). However, due to the nature of a complete replacement project, there are fewer variables and unknown conditions associated with its construction that could affect the construction schedule and cost.
4	**Do Nothing:** In the event that a consensus cannot be reached or budgetary constraints dictate that no action be taken, the "Do Nothing" alternative is an option. Movement of the arch stones is expected to continue however, the rate at which this occurs depends upon many variables, not the least of which is Maine's unpredictable weather patterns.	$0	• Lowest cost Alternative in the short term. • Results in no environmental or property impacts. • Favorable weather patterns may allow for continued use of the structure.	• Roadway closure due to continued deterioration and movement anticipated in the next 1 to 3 years. • Further decline in the structure's condition may rule out any rehabilitation Alternative from being feasible. • Eventual loss of a historic structure.

Attachment B

Renderings of Replacement Structures (11x17)

BEFORE

AFTER

CONSULTING ENGINEERS

SIMPSON ROAD OVER
STACKPOLE CREEK

Scale: N.T.S
Date: 3/11

BEFORE

AFTER

CONSULTING ENGINEERS

SIMPSON ROAD OVER
STACKPOLE CREEK

Scale: N.T.S
Date: 3/11

BEFORE

AFTER

CONSULTING ENGINEERS

SIMPSON ROAD OVER
STACKPOLE CREEK

Scale: N.T.S
Date: 3/11

Attachment C

Wall Photos

Low Relief Concrete Formliner (1.1/4” relief, no stain)

Medium Relief Concrete Formliner (2.1/2” relief, no stain)

High Relief Concrete Formliner (4.3/4” relief, with stain)

This space intentionally left blank.

Plain concrete retaining wall prior to application of stone veneer

Stone veneer installation in progress (same structure as in top photo)

Full size stone façade installation in progress

Full size stone façade on complete abutment

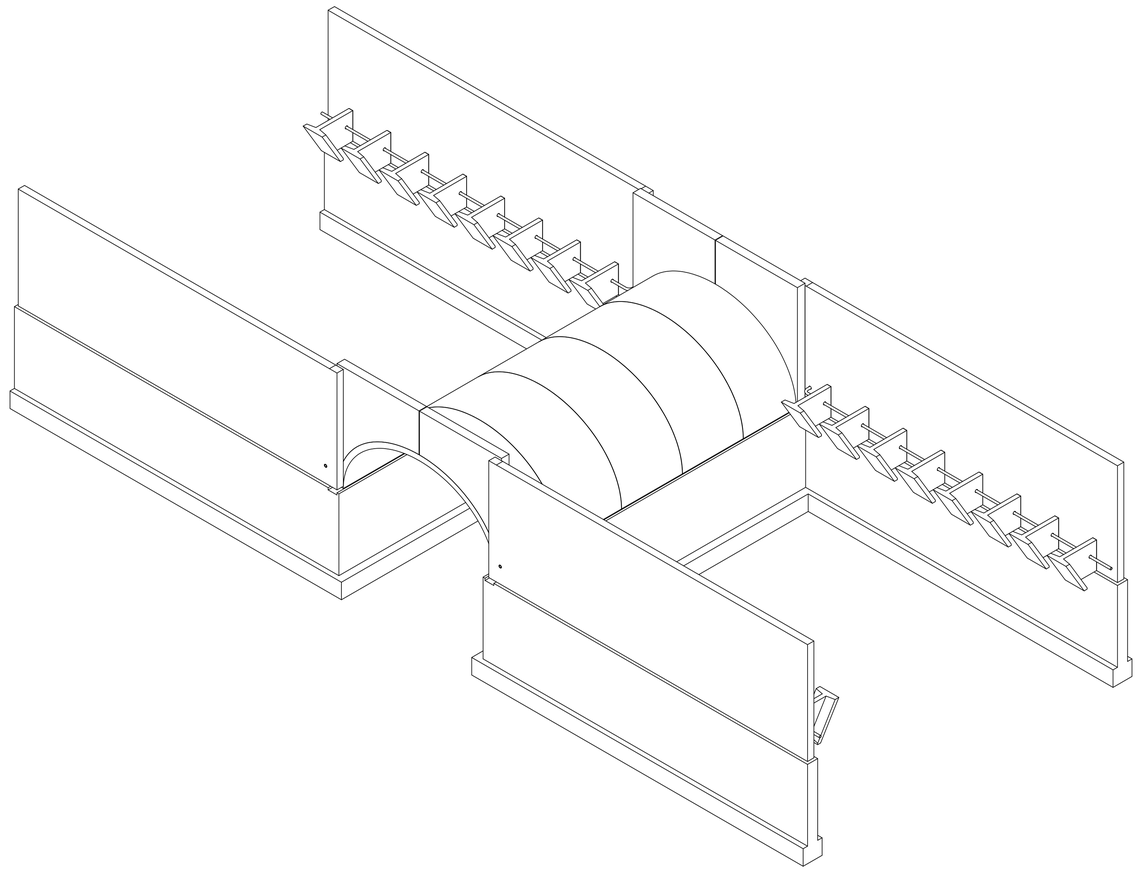
Attachment D

BEBO Sketches

Saco, ME Bridge Replacement

Saco ***ME***

Upstream



Downstream

ISOMETRIC VIEW

Preliminary Drawings prepared for:

Justin

Reardon

BEBO® Arch Systems
3100 Research Blvd. P.O. Box 20266 Dayton, Ohio 45420-02366
Phone: (800) 526-3999 Fax: 937-254-8365
www.con-span.com

ME

Saco, ME Bridge Replacement

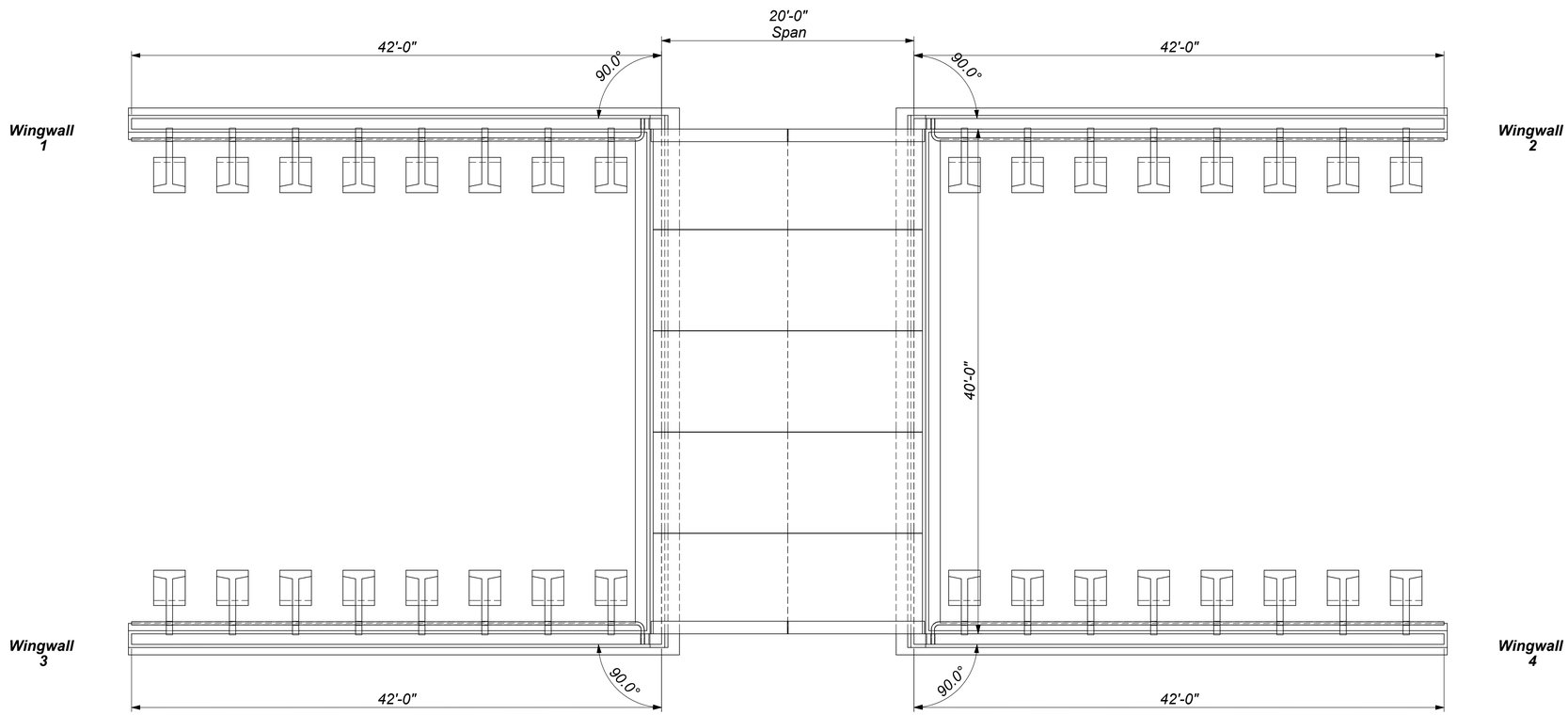
Saco

Date: 03/11/11

DYOB No. 132396

Sheet No. **1**

Upstream



Downstream

BRIDGE PLAN

Preliminary Drawings prepared for:

Justin

Reardon

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Phone: (800) 526-3999 Fax: 937-254-8365
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ME

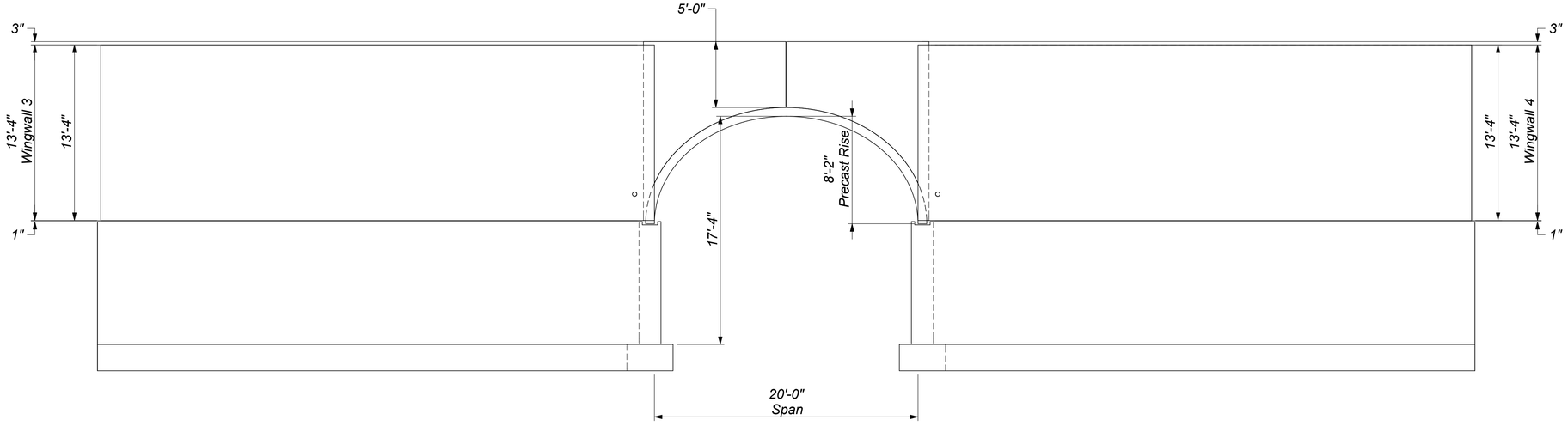
Saco, ME Bridge Replacement

Saco

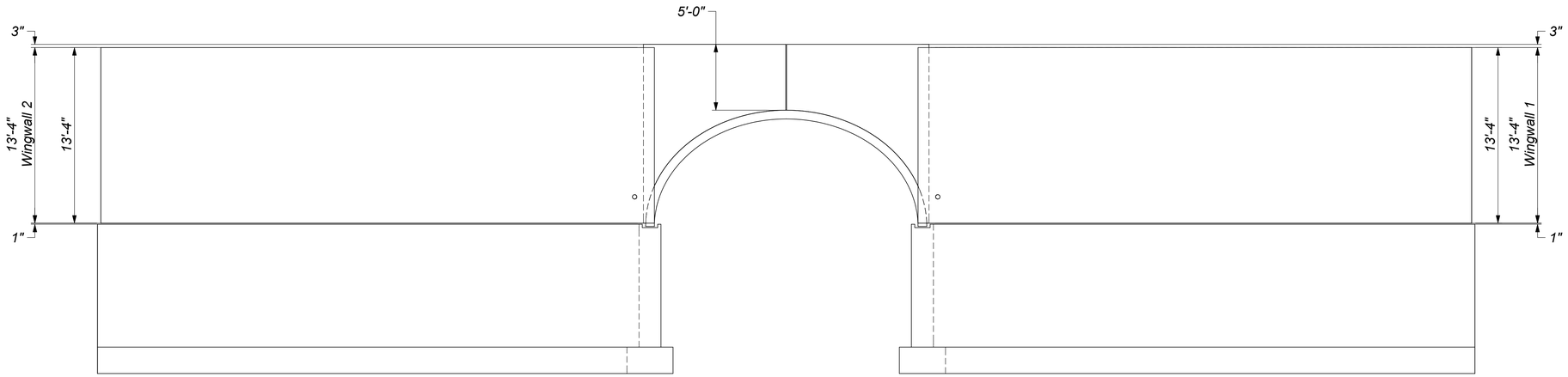
Date: 03/11/11

DYOB No. 132396

Sheet No. **2**



DOWNSTREAM END ELEVATION



UPSTREAM END ELEVATION

Preliminary Drawings prepared for:

Justin

Reardon

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ME

Saco, ME Bridge Replacement

Saco

Date: 03/11/11

DYOB No. 132396

Sheet No. **3**

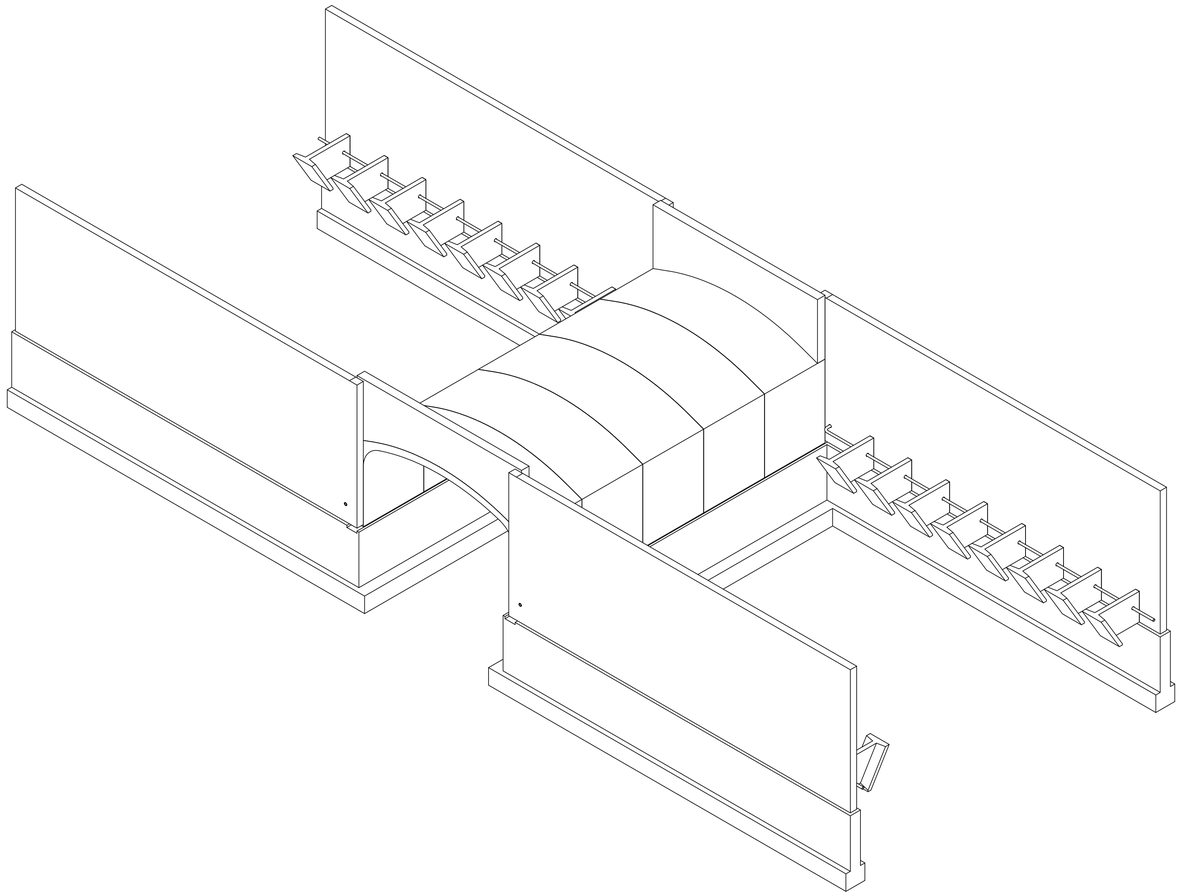
Attachment E

Conspan Sketches

Saco, ME Bridge Replacement

Saco ***ME***

Upstream



Downstream

ISOMETRIC VIEW

Preliminary Drawings prepared for:

Justin

Reardon

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www.con-span.com

ME

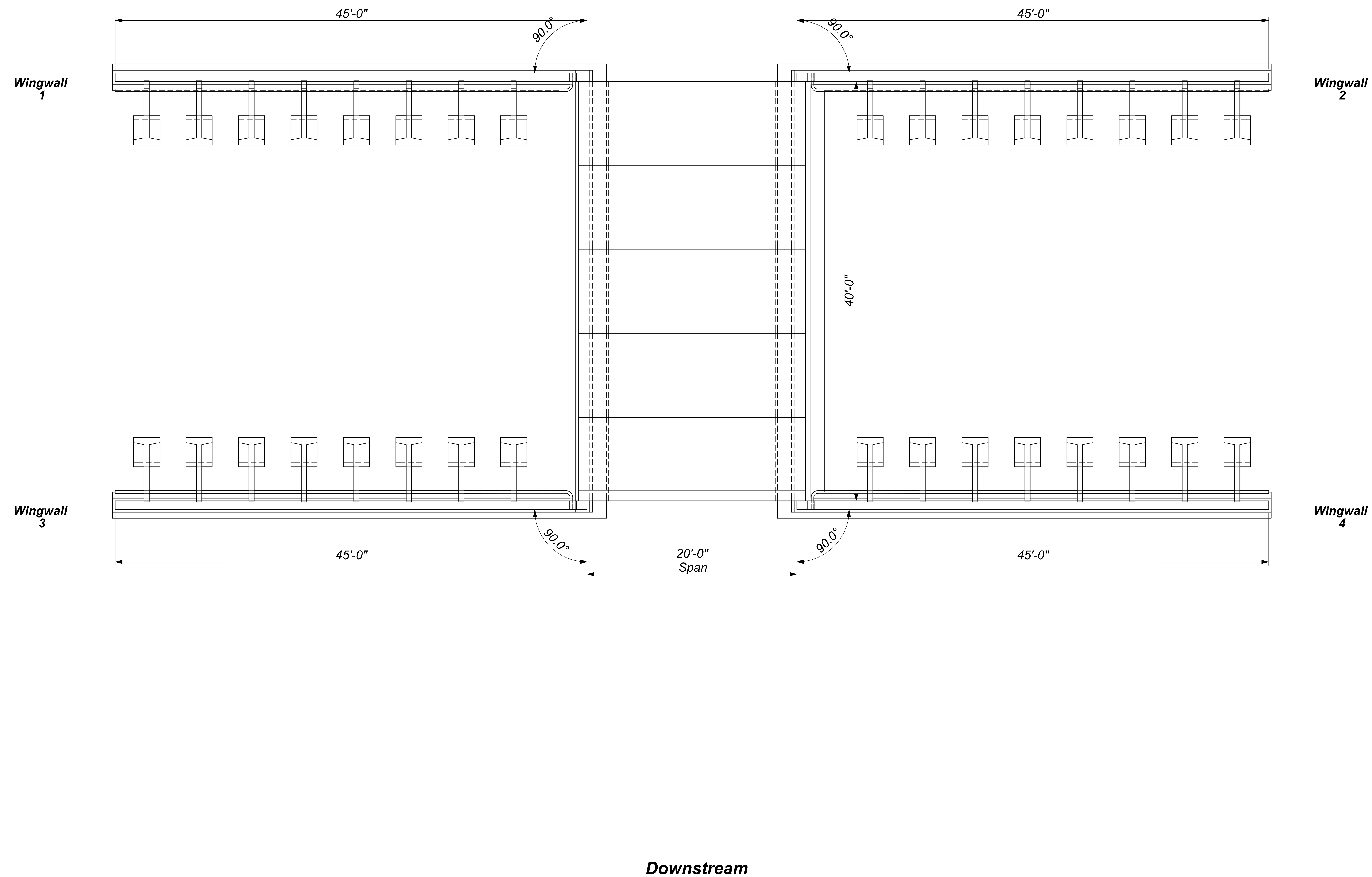
Saco, ME Bridge Replacement

Saco

Date: *03/11/11*

DYOB No. *132398*

Sheet No. ***1***



BRIDGE PLAN

Preliminary Drawings prepared for:
Justin Reardon

CON/SPAN® BRIDGE SYSTEMS
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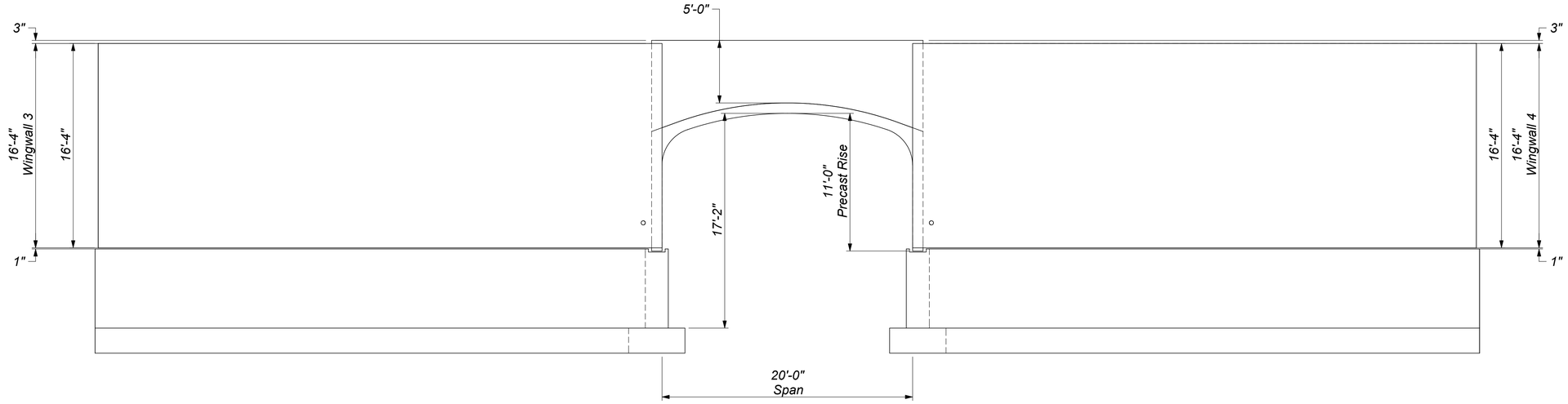
Saco, ME Bridge Replacement

Saco ME

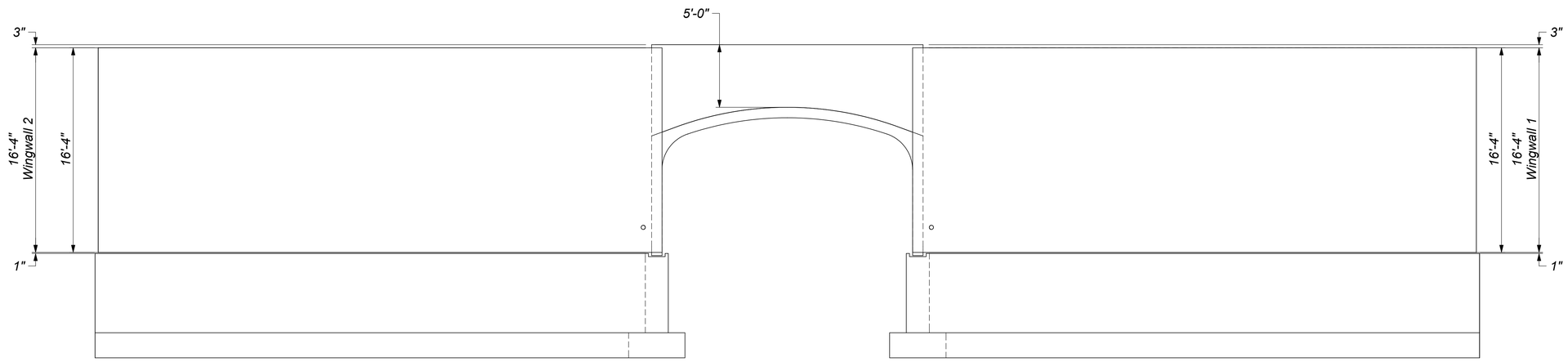
Date: 03/11/11

DYOB No. 132398

Sheet No. **2**



DOWNSTREAM END ELEVATION



UPSTREAM END ELEVATION

Preliminary Drawings prepared for:

Justin

Reardon

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Saco, ME Bridge Replacement

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Sheet No. **3**

Attachment F

Existing Structure Comparison Photos

1st Radial Crack – June 11, 2003

1st Radial Crack – January 11, 2011

2nd Radial Crack – June 11, 2003

2nd Radial Crack – January 11, 2011

Upstream Face – July 28, 2004

Upstream Face – January 11, 2011

January 20, 2012

Mr. Michael Bolduc
Public Works Director
City of Saco
300 Main Street
Saco, Maine 04072

Re: City of Saco
Simpson Road Stone Arch Culvert
CLD Reference No. 09-0248.0040

Dear Mike:

On December 22, 2011, CLD Consulting Engineers, Inc. performed an on-site inspection of the Simpson Road stone arch culvert, at the request of the City of Saco. Included herein is an update on the current structure condition and level of deterioration, along with a recommendation for action.

CURRENT CONDITION

It is apparent through visual observation that the rate of deterioration of the stone arch culvert has significantly accelerated over the past year. Evidence of deterioration includes loss of mortar, expansion of gaps between stones, rotation of individual stones, undermined foundation stones, and delamination of steel bracing.

Loss of Mortar
The mortar along the interior face of the culvert and between arch stones was inspected and found to be severely deteriorated. Large chunks of mortar were found on top of the horizontal steel bracing members. Piles of mortar that had crumbled into a fine aggregate consistency, similar to sand, were found at the downstream end of the culvert. Other sections of mortar still in-place between wall stones immediately crumbled when touched.

General Outward Movement of Upstream End
In September of 2009, gauges were installed across various gaps between stones located on the interior walls and arch of the culvert. Since then, City of Saco personnel have monitored the gauges and kept a record of the readings at various time intervals. As stated in the summary report letter, dated March 15, 2011, the gauge readings indicate the upstream third of the arch continues to move outwards. It was found that this movement outward has progressed over the past year.

The gap for this radial crack increases in width after each winter season by approximately 2.5 mm and remains fairly constant during the spring, summer, and fall months. This can be attributed to the freeze/thaw cycles occurring within the bridge backfill, acting upon the arch and abutment stones.

Large Gaps Between Stones
Large gaps between stones that extended two to three feet into the wall, were found at various locations. It is likely that these gaps previously were filled with stones, mortar, or grout bags. The depth of these gaps is likely to continue to increase due to migration of fine backfill soils and scour during periods of high stream levels and velocities.

Dislodged Foundation Stone and Scouring
A major structural granite block located on the downstream 'Saco end' of the culvert has rotated 90 degrees out from the wall and is caught against a steel bracing column. It is likely this stone became dislodged from the wall due to high stream velocities scouring away the surrounding mortar and backfill. During the site inspection, the lower three to four feet of the walls were submerged by the stream. Using a large stick to prod along the submerged sections of wall, large sections of scour were found along both sides of the culvert. It is recommended that during low flows, the lower levels of the culvert be inspected to ensure no other foundation stones have become dislodged.

Please note that grouting of stones within the bottom 3-feet of the wall was recommended as an interim measure in the previous letter dated, March 15, 2011.

Rotated Keystone
Near the downstream end of the culvert, one of the keystones in the arch (top, center stone) appears to have rotated approximately 3-inches below the inner face of the arch. Movement of this type of stone is particularly alarming since it locks the other stones of the arch in position and allows the arch structure to withstand vertical loads. If a keystone becomes dislodged, failure of the surrounding components of the arch will occur. The vertical loads supported by the arch are transferred to the walls of the culvert, which help to withstand the lateral earth pressures acting upon the back of the wall.

Delamination of Steel Bracing
Surface rust covers all of the steel members, and the walers (horizontal I-beam supports) have begun to delaminate, with notable section loss. This bracing was installed in December 2001, and at that time was considered to be a temporary stabilization measure, anticipated to be in place for two-years. During the inspection, large sections of delaminated steel simply fell into the stream when the waler was grabbed.

Dislodged Timber Blocking
Timber blocking attached to the walers was dislodged or missing in some locations. This blocking is designed to be wedged tightly between the culvert walls and the steel walers, in order to prevent any further movement of the stones.

RECOMMENDATION

The previous summary letter sent to the City of Saco, dated March 15, 2011, regarding the Simpson Road stone arch culvert provided a list of rehabilitation and replacement options, along with the advantages and disadvantages of each option. It is our understanding that a consensus regarding rehabilitation or replacement was not reached and therefore the "chosen" alternative has defaulted to "Alternate 4: Do Nothing." One of the disadvantages for "Alternate 4: Do Nothing", stated that further decline in the structure's condition may rule out any rehabilitation alternative from being feasible. Unfortunately, with the level of deterioration that has occurred over the past year, this statement may have become a reality and a full replacement is the most feasible alternative at this point.

Due to the current condition described above, CLD Consulting Engineers, Inc., recommends, at minimum, that the Simpson Road stone arch culvert be closed prior to any forecasted rainfall event with a total anticipated precipitation greater than one inch over a 48-hour storm duration, or less. The road over the culvert should also be closed during periods of high water levels (depths of 5 feet or greater) caused from snow melt conditions. Following any roadway closure, it is important that the bridge be inspected prior to re-opening to the public.

Considering the movement documented over the last two years, most of which takes place over the winter season, it is expected that the large radial gap on the upstream end of the culvert will continue to expand. This current winter season has already experienced excessive freeze thaw cycles that may result in rapid deterioration. We would recommend the City perform weekly observation of the structure, followed up with a formal engineering inspection in the Spring. CLD Consulting Engineers, Inc. should be notified immediately if gauge readings indicate movement greater than 2mm, in comparison to the October 26, 2011, readings.

If any further movement occurs, it is highly probable that a recommendation for closure will be issued. The City of Saco is advised to prepare for permanent closure accordingly at this time.

Please do not hesitate to contact us with any questions, or if more information is required.

Very truly yours,

Ryan McCarthy, P.E.
Project Engineer

JoAnn L. Fryer, P.E.
Branch Manager and Senior Associate

RMM/kb

June 13, 2012

Mr. Michael Bolduc
Public Works Director
City of Saco
300 Main Street
Saco, Maine 04072

Re: City of Saco
Simpson Road Stone Arch Culvert
CLD Reference No. 09-0248.0040

Dear Mike:

On June 11, 2012, CLD Consulting Engineers, Inc. performed an on-site inspection of the Simpson Road stone arch culvert, at the request of the City of Saco, due to an extended period of rain from June 2nd through June 4th. It was reported that 5 inches of rain fell on June 2nd, 1.5 inches on June 3rd, and 0.5 inches on June 4th. Prior to the rain events, the City of Saco closed the bridge as a precautionary public safety measure, in accordance with a recommendation from our last inspection report letter, dated January 20, 2012, documenting the annual inspection completed in December 2011.

Based upon review of the surrounding terrain and vegetation, it appears the water level was approximately 12- to 15-feet (near the arch spring line) on the upstream side, during the storm event. Significant debris apparently built up on the upstream side and a majority was removed by the City crews prior to our inspection. Water levels at the time of inspection were approximately 18" upstream; and approximately 3 feet deep in the structure.

Photos were taken to document any further movement and deterioration, to compare to previous visits. Included herein is an update on the current structure condition and level of deterioration, along with a recommendation for action.

CURRENT CONDITION

The condition of the culvert has continued to decline at a constant rate over the past six months. Evidence of deterioration, as stated in the previous inspection report dated January 20, 2012, includes loss of mortar, expansion of gaps between stones, rotation of individual stones, undermined foundation stones, and delamination of steel bracing.

Loss of Mortar
Mortar located between stones continues to deteriorate and become dislodged. Large chunks of mortar and small piles of fine aggregate, found on top of the horizontal steel bracing members provide evidence of a constant loss of mortar. In addition, it was noted that the downstream concrete wingwall appears to have more spalling adjacent to the stone structure, reducing the bond between concrete and stone, as compared to the photos taken in December 2011.
General Outward Movement of Upstream End
It was stated in the previous inspection report. dated January 20, 2012, that the gap of the upstream radial crack appears to increase in width after each winter season, by approximately 2.5mm. This increase was documented during the 2009/2010 and 2010/2011 seasons. As expected, the gap has increased again during the 2011/2012 winter season by another 2.0mm; however, it should be noted that the recent storm did not change the readings along this radial crack.

Large Gaps Between Stones
It was stated in the previous inspection report dated, January 20, 2012, that large voids between stones extend approximately two to three feet into the walls. The depth of these voids has more than doubled in the past six months, to depths greater than 6 feet in some locations. This rapid increase in void size can likely be attributed to scour caused by the high stream velocities during the recent rain event.

Dislodged Foundation Stone and Scouring
The bottom 4-feet of the interior portion of the arch culvert was submerged during the inspection and could not be observed. This area is of utmost concern as it is the foundation to the structure. The dislodged foundation stone previously observed appears to be in the same location, rotated 90 degrees out from the wall and caught against a steel bracing column; however it was not possible to determine if other stones have become dislodged or the extent of scouring that is known to exist. Please note that grouting of stones within the bottom 3-feet of the wall was recommended as an interim measure in both the March 15, 2011, annual inspection letter and the most recent January 30, 2012, letter.

Rotated Keystone
The rotated keystone near the downstream end of the culvert does not appear to have shifted since the last inspection, measured at 2.5 inches. As stated previously, movement of this type of stone is particularly alarming since it locks the other stones of the arch in position and allows the arch structure to withstand vertical loads. If a keystone becomes dislodged, failure of the surrounding components of the arch will occur.

Delamination of Steel Bracing
The steel members and walers (horizontal I-beam supports) continue to delaminate, with notable section loss. They are still currently providing some stability to the structure, but the structural integrity will continue to degrade with time.

Dislodged Timber Blocking
Timber blocking attached to the walers was found to be dislodged or missing in some locations not previously noted. This blocking should be wedged tightly between the large stones that make up the culvert walls and the steel walers, in order to help prevent any further movement of the stones.

Upstream Silt and Debris
Debris caught on the lowest horizontal steel bracing at the upstream end of the culvert has caused silt to build up in the channel, up to the elevation of the bottom bracing. The debris should be removed as soon as possible to allow the silt/sand to wash downstream. This should lower the water level within the culvert so that more of the bottom stones can be observed.

RECOMMENDATION

The recent rain storm events do not appear to have caused any localized structural failure, above the current deterioration; however, there appears to be significant additional loss of soil, small rocks and mortar from between the large stones and behind the walls. The deterioration of the structure continues in

the same manner as documented and expressed in our previous inspection report, dated January 20, 2012. Given the limitations and risks presented in the previous inspection report, the City of Saco could proceed with reopening the bridge. It is our understanding that there is one inch of rain forecasted for today and that the reopening of the bridge will be delayed until tomorrow at the earliest, when it can be evaluated consistent with the protocol provided in the previous report.

The following outline of future tasks is recommended.

1. Remove remaining debris to allow passage of silt/sand.
2. Monitor road surface for sinkholes or additional cracking. Voids were found to extend into the abutment backfill which will likely create cracks and potential sinkholes in the pavement.
3. Visually inspect the bottom 4-feet of the interior walls when the water level drops.
4. Determine plan of action for bridge replacement or rehabilitation by September 2012.
5. If bridge is to remain as-is past September 2012, the following is recommended:
    a. Cofferdams and bypass pumps be setup temporarily to allow full inspection of the bottom 4-feet of the culvert and foundations. Voids found within the bottom 5-feet of wall should be filled with mortar to protect against scour.
    b. Replacement of timber blocking between bracing and stones that has been dislodged.

If any further movement occurs, it is highly probable that a recommendation for closure will be issued. The City of Saco is advised to prepare for permanent closure, accordingly, at this time.

Please do not hesitate to contact us with any questions, or if more information is required.

Very truly yours,

Ryan McCarthy, P.E.
Project Engineer

JoAnn L. Fryer, P.E.
Branch Manager and Senior Associate

RMM/kb

May 14, 2013

Ms. Angela Blanchette
City Engineer
City of Saco
300 Main Street
Saco, Maine 04072

Re: City of Saco
Simpson Road Stone Arch Culvert
CLD Reference No. 09-0248.0040

Dear Angela:

On May 8, 2013, CLD Consulting Engineers, Inc. performed an on-site inspection of the Simpson Road stone arch culvert's bottom 4-feet and foundations, at the request of the City of Saco, per CLD's earlier recommendation. Included herein is an update on the condition of the abutment foundation and steel frame's posts, along with a recommendation for action. The attached sketch encompasses the findings of this inspection.

The culvert's foundation was inspected as the water levels were being drawn down by the City. The water level was approximately 1.5-feet deep during the duration of the inspection. The submerged portion of the abutments' foundation was inspected via probing. Voids were found during the inspection which were photographed and documented accordingly. As CLD probed for voids, deposits of silt and sand were found which will likely be washed away during large storm events. The foundations for the steel frame's posts were found to be in good condition.

CLD compared the findings of this inspection to the September 2001 inspection report to determine the relative condition of the foundation. As expected, the structure continues to deteriorate. There are some areas that remain consistent with the level of deterioration found in 2001; other areas have continued to deteriorate significantly, and new areas, particularly large voids, have since appeared.

Recommendation: CLD has reviewed the new information and discussed this matter in great detail. Given the continued deterioration, loss of backfill and stones through voids, and unpredictability of the future performance of the structure, we do not feel that it is prudent to re-open the structure until significant rehabilitation and/or replacement occurs. We would also recommend that permanent barriers be placed to restrict all traffic from using the bridge.

Please do not hesitate to contact us with any questions, or if more information is required.

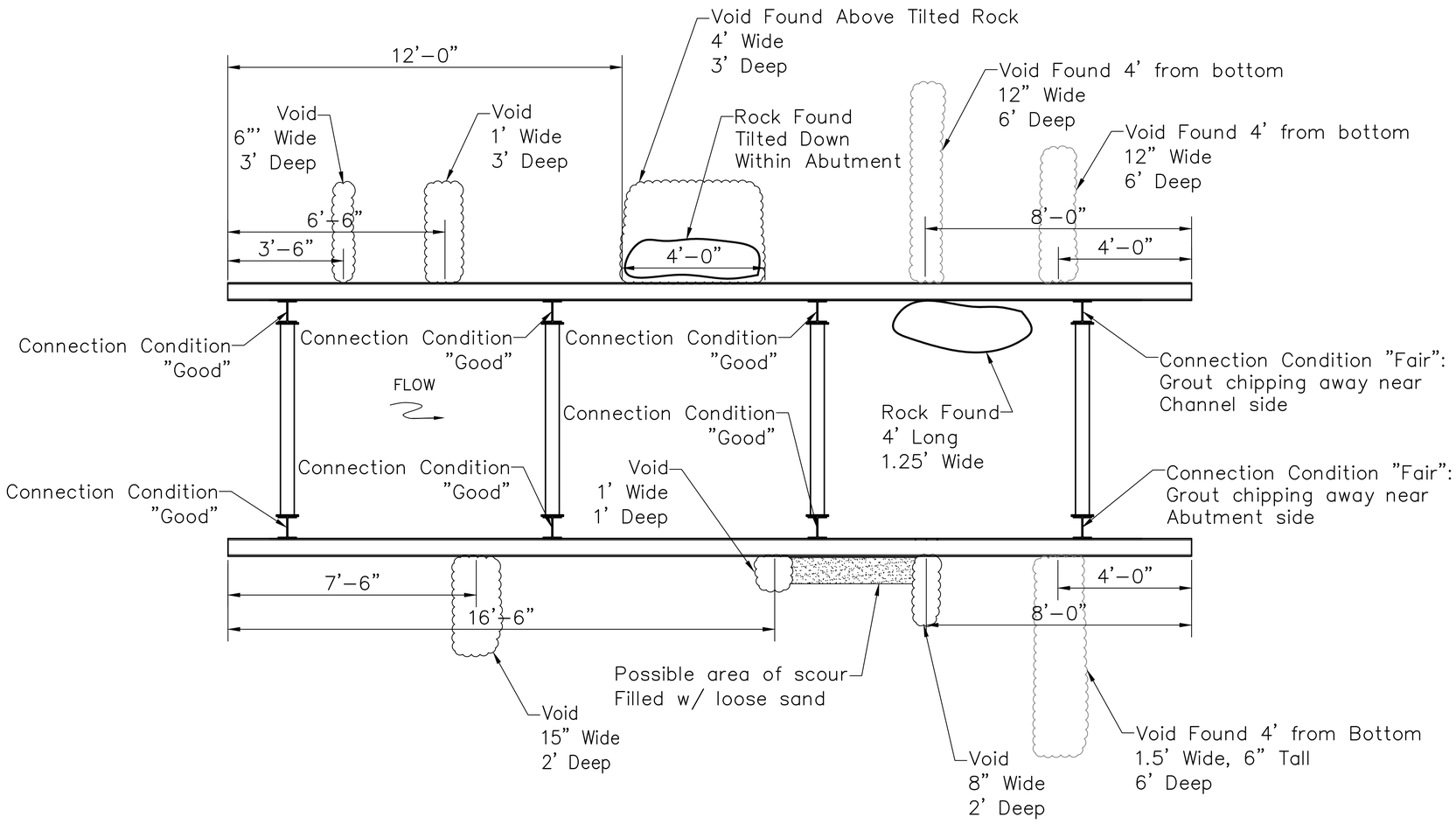
Very truly yours,

Ryan McCarthy, P.E.
Project Engineer

JoAnn L. Fryer, P.E.
Branch Manager and Senior Associate

RMM/kb
Enclosures

* Voids Located Below Lowest Bracing (Bottom 2 feet) Unless Otherwise Noted



MAY 8, 2013
BRIDGE INSPECTION

NO.	DATE	REVISION

DRAWN: JAD | DESIGNED: JAD | CHECKED: RMM | APPROVED: JLF

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SACO, MAINE 04072

SIMPSON ROAD
STONE ARCH INPSECTION
SIMPSON ROAD
SACO, ME

FOUNDATION INPSECTION SCOUR & VOID LAYOUT

SCALE:	JOB NO.
1"= 2'	09–0248.0040
DATE: MAY, 2013	DWG. F1
	1 OF 1